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National Aeronautics and Space Administration

Twenty-fifth Anniversary 1958-1983

Notable views of notable people on aerospace matters...

aerospace perspectives

William H. Gregory, *Editor-in-chief, Aviation Week & Space Technology, in an editorial in that publication:*

"Congressional complaints and a draft report from the Defense Department's inspector general about pricing for spares have criticized military procurement managers for paying far more than necessary for such hardware. By implication, the report and the furor in Congress have also charged that aerospace companies are habitually gouging the government on spares pricing. . .

"Inaccuracies are being tossed around among all the charges. Bendix turned up in one media list with steep price increases on three different items. In the case of two of them, the early and the later prices were reversed. The price had gone down over time, not up. In the third case, as in many of the spares allegations, there was no mention of quantity. The early year price was based on a quantity of 300. The second year buy was one. The third year was 300. That single item buy left the impression of a monstrous price increase, when the first to third year comparison was not out of line. . .

"The inspector general's report . . . is confusion compounded. It is not clear what base prices are being cited. Quantities are not cited in statistics, yet quantity is a key factor in determining unit price. It is not clear whether surplus parts are being compared with newly manufactured parts. Surplus parts are obviously less costly, but great care has to be used in checking quality to ensure that they meet standards—that, for example, they are not factory rejects. One analyst said that as much as 50 percent of the actions cited as increases in the inspector general's report turned out to be price decreases on further checking. . .

"When some of the quirks in the defense procurement system are factored into spares pricing, the prices may still seem remarkable, but become more understandable. As an example, overhead and handling charges are billed in spares prices. On high value equipment, like an engine, such charges are a relatively small proportion. On small items like nuts and bolts, the indirect and paperwork charges—particularly in small quantities—can indeed make the price look ridiculous. . .

"If Congress and the Defense Dept. hierarchy want to get to the bottom of spares pricing, they ought to look at the whole spectrum of how defense procurement regulations and policies affect the way costs are structured and how handling charges and overhead are allocated. They should also look at what kind of quantities are being ordered. Further, they should consider how much paper is involved in federal procurement and how the paperwork involved is loaded onto the price of a part.

"Defense procurement regulations and procedures are so complex even experts do not fully understand them. As absurd as some buying seems to the public, there is almost always a rationale for it if no other than just following standard rules and procedures. A lot of hardworking and knowledgeable professionals in the procurement process in both industry and government are being unfairly—or outright wrongly—pilloried before the public in the spares circus now being staged by amateurs. There is plenty of room for improvement, but the horror stories being bandied about are a distorted picture."

Robert Ames, *executive vice president-aerospace, Textron, Inc. and chairman of the Board of Governors of Aerospace Industries Association, in testimony before the Subcommittee on Economic Stabilization, House Committee on Banking, Finance and Urban Affairs:*

"Clearly, the U.S. must develop positive countermeasures to offset, to the degree possible, the competitive advantages accruing to foreign manufacturers as a consequence of the support they receive from their governments. But fundamental differences between the U.S. and foreign economic, political and social systems render it unlikely that the U.S. government can, will or should provide its exporting industries with the extent of support that our foreign competitors enjoy.

"Rather, our best response lies in a traditional American strength: technological innovation. The U.S. has not lost its technological capability—only its momentum. The first critical step in regaining that momentum is fostering the recognition—within the Administration, the Congress and the American people—that American preeminence in science and technology is of paramount importance to the U.S. economy, the nation's security and its standard of living.

"That recognition must then be implemented through a *comprehensive* government policy concerning the conduct of industrial research and development. This policy should accord a higher national policy to R&D than has previously been the case; encourage more effective cooperation among government, industry and the academic community; advocate new incentives to expand industrial R&D; and acknowledge and maintain the strengths associated with competitive, decentralized decision-making by industry."

Representative Melvin Price, *Illinois, chairman of the House Armed Services Committee, in a Congressional debate over funding for antisatellite weapons, as reported by the Congressional Record:*

"An information sheet by the Center for Defense Information (stresses) that the United States should not proceed with an antisatellite system because it would destroy the opportunity to get an agreement on limiting such space systems . . . The Center . . . concedes that the Soviets have an antisatellite system and that they continue to test it. The Center's extensive discussion does not suggest that the Soviets stop testing their antisatellite system or be asked to stop deployment of their operational system.

"What is simply not clear to me is why we should not even develop any capability in this area. The Center does not explain why it is no threat to peace if the Soviets have a system deployed, as they do, but it somehow would risk a war in space if the United States even tests such a system. . .

"I think we should try to get away from listening to those who loosely throw out the idea that you cannot deploy any weapon that might threaten the other side's weapons in a time of crisis because they might quickly go to a use-them-

or-lose them strategy. I do not think any side is going to quickly conclude that a first strike is advantageous simply because the other side has weapons that could take out some strategic weapons or some satellite systems. It is to my mind fuzzy thinking to suggest that people are going to act in a hair-trigger way with nuclear weapons. I do not think the leaders on either side are that crazy."

Albert Wohlstetter, *president of the European-American Institute for Security Research, writing in Commentary:*

"Many of the ostensible goals of arms agreements are best achieved through measures which we can and should implement on our own. Our current efforts—which a freeze would stop—to design and deploy nuclear weapons which are more accident-proof, and more secure against theft or unauthorized use, are a good example.

"These (measures) need not mean a net increase in the numbers or destructiveness of nuclear weapons in our stockpile . . . If we increase precision further, we can drastically reduce the number and destructiveness of our nuclear weapons. Increased precision can also improve the effectiveness of conventional weapons so that they may increasingly replace nuclear brute force. And it would improve our ability to avoid the unintended bombing of innocents with nuclear or conventional warheads. It would enlarge rather than foreclose our freedom to choose."

Carlton E. Spitzer, *senior vice president, Manning, Selvage & Lee, Washington, D.C., writing in Public Affairs Review:*

"The politican claims he cannot take the long view because he must respond to the immediate cries of his constituents and those who support his campaigns. The business executive says he cannot take the long view because he is judged on the next quarterly earnings statement. The banker and investor too often agree with him. The labor leader cares about America's future as much as the next man but today's jobs are the issue and he argues for propping up dying industries and keeping foreign-made products out of our stores. The appointed government bureaucrat says his actions must support the administration that put him behind his desk. Everyone must deal with the here and now. Who, then, builds for the future?"

McAllister Retires

Regular *Aerospace* readers may note the absence of a familiar name in the adjacent masthead, that of Gerald J. McAllister, editor of *Aerospace* since its inception in 1963. After more than 27 years service with Aerospace Industries Association, McAllister has retired. His editorial talent, experience, good humor and extensive knowledge of the aerospace industry will be sorely missed.

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EDITOR • John F. Loosbrock
ASSOCIATE EDITORS • James J. Haggerty
Laura Overstreet
Jean Ross Howard
ART DIRECTOR • James J. Fisher

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The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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NASA: 25 Years... and the Next 25

BY JAMES J. HAGGERTY

Chances are you don't remember Pioneer 1, even if you're old enough to have witnessed the beginnings of U.S. space flight. It was no big deal, a 1958 lunar probe that failed to go the distance but was hailed as a milestone because it reached an altitude of 70,000-plus miles. It has a more legitimate claim to milestone status in that it was NASA's first spacecraft.

Pioneer 1 was launched on October 11, 1958, just 10 days after NASA officially opened its doors for business. So, on October 1 or October 11, depending on your viewpoint, NASA will mark its 25th anniversary of space operations. The aeronautical research component of NASA's work, acquired in 1958 from the old National Advisory Committee for Aeronautics (NACA), dates back to 1915, when NACA was created.

In its 25 years of existence, NASA has compiled an extraordinary record of exciting accomplishment, technological excellence and managerial competence. Its efforts have contributed immeasurably to restoring and maintaining the once-tarnished U.S. image as world leader in science and technology and, at the same time, they have generated a wealth of benefit to the nation, even if the benefits are sometimes only dimly perceived.

NASA's space science program, which has produced more knowledge of the solar system and the universe than man had acquired in all the prior years of history, represents a practical as well as a scientific benefit, because the immense volume of information gathered provides a broad foundation for future technology development.

The agency's pioneering work on space applications—direct benefit systems—paved the way for the communications and environmental satellites now in operational service. It promises future benefits of even greater potential, such as Earth resources monitoring for more effective management of the planet's resources and orbital manufacturing of products not producible on Earth.

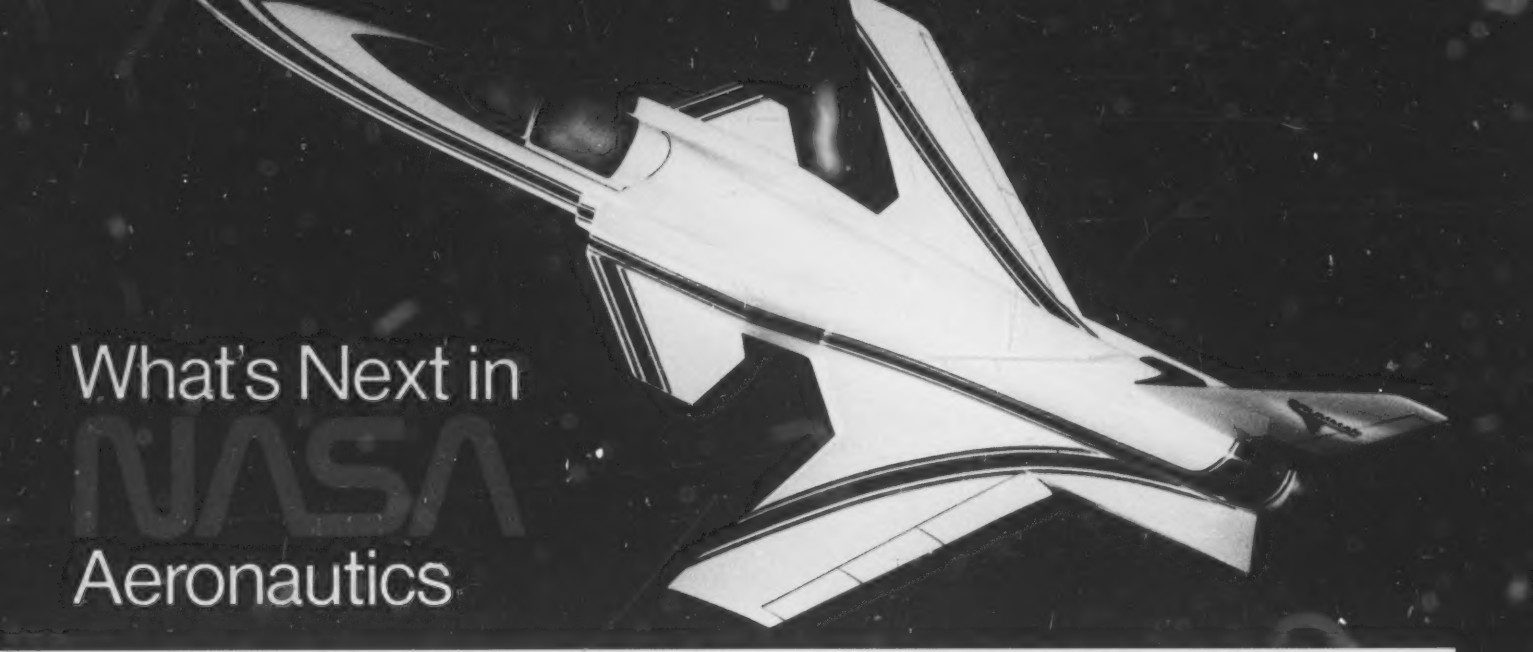
NASA aeronautical research has generated a succession of technology advancements of great benefit to the U.S. in terms of the national economy, stronger defense, improved competitiveness of American aircraft manufacturers, reduced environmental impact of the airplane and greater safety for all who fly.

And the "spinoff" or secondary use of technology developed in all these programs has produced literally thousands of new products and processes, which in turn created new jobs, in some cases whole new industries.

For all its dramatic accomplishments, NASA's first quarter century has been largely a period of development, a time of building advanced capability not only to explore space but to exploit it. The Space Shuttle is a big step in that direction; providing routine access to orbit, it offers an opportunity to pursue some of the direct benefits space promises. But real exploitation of space will require considerably more capability development—the space station, for example, and a variety of new systems associated with it.

So NASA's second quarter century will see the civil space program proceeding simultaneously on two fronts. On the one hand, NASA will be developing advanced technology for a permanent, substantially broadened manned presence in space. On the other, we will see the beginning of a major new thrust in exploiting space for direct Earth benefit, initially in such areas as orbital manufacturing, monitoring Earth's land and sea resources on a global scale, advanced space communications and long range environmental prediction.

How these advances will be pursued is outlined in the latest NASA Program Plan, which details what agency thinkers have in mind for coming years. Many of the programs it describes are already approved and launched; others represent a kind of "wish list," projects that are logical and profitable extensions of current effort, feasible in a certain time frame; they are good possibilities for tomorrow but are not yet approved or funded for hardware development. Collectively, the ongoing and hopefully-comtemplated programs paint an exciting picture of the civil space future; they are summarized in the following pages.



What's Next in NASA Aeronautics

A unique new airplane will take to the skies next spring, probably startling some observers; they may think its wing was installed backward. The plane is the Grumman-built X-29A, featuring wings swept forward instead of aft; this design technique, coupled with use of composite materials, offers potential for building aircraft lighter, smaller and less costly than equivalent performance planes with aft-swept all-metal wings.

The X-29A is one example of NASA's High Performance Aircraft Program, conducted in cooperation with the Department of Defense and industry. The program is directed toward advancing technologies that will find first use in military aircraft but which also promise future benefits in civil aircraft applications. Among other projects are the General Dynamics AFTI F-16 and AFTI F-111, both part of the joint USAF/NASA Advanced Fighter Technology Integration program. Already in flight status, the AFTI F-16 features all-electronic flight controls instead of the conventional assembly of rods and linkages. Scheduled for first flight next summer, the AFTI F-111 will have a Boeing-fabricated wing whose camber is automatically changed as flight conditions change, optimizing cruise performance and maneuverability.

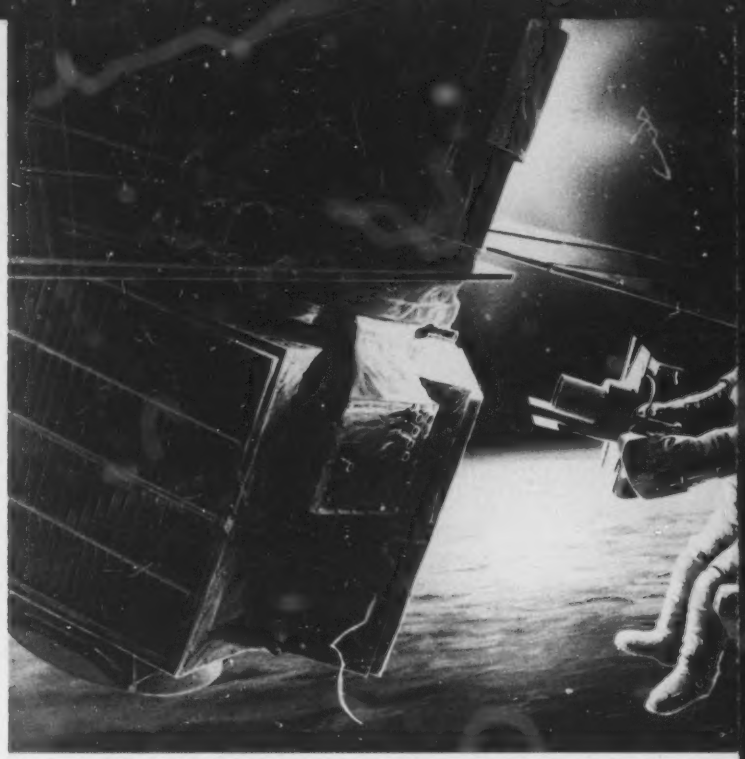
A fourth project is a NASA/General Dynamics investigation of the "arrow wing" technology, originally developed by NASA for supersonic civil transports, in a modified fighter known as the F-16XL; two XLs are undergoing flight test. NASA's High Performance Aircraft Program also includes design and model testing of advanced fighter/attack concepts and laboratory tests of advanced propulsion systems.

In civil aircraft research, a project of special NASA focus is the Advanced Turboprop, which offers jetlike commercial transport speeds with fuel consumption 15 to 20 percent lower than turbofan engines. NASA recently launched development of an advanced turboprop test assembly—propeller, engine, gearbox—to begin flight evaluation in 1987. NASA is also conducting an Energy Efficient Transport Program that combines engine fuel efficiency with use of electronic flight controls for a sharp reduction in fuel consumption. The agency's work on composite materials, usually lighter yet stronger than the metals they replace, has resulted in use of composites as secondary structures on new jetliners; the next step, now under way, is to develop technology for application of composites in *primary* structures of large civil and military transports, a step that can provide really dramatic weight, fuel and cost savings.

In rotorcraft research, NASA will continue to fly the Bell Helicopter Textron XV-15 Tilt Rotor Research Aircraft, expanding the operational envelope to provide data useful to the Department of Defense in its JVX tilt-rotor development. NASA will also continue its advanced helicopter investigations with the Sikorsky-built Rotor Systems Research Aircraft (RSRA), a flying laboratory for testing various rotors applicable to future helicopters or compound helicopters. A major new start in FY 1984 will be a joint program with the Defense Advanced Research Projects Agency (DARPA) to investigate further the "X-wing" concept, in which a wide-bladed rotor system used for vertical lift converts to a fixed wing for forward flight. DARPA conducted several years of wind tunnel experimentation; the new program will involve design and fabrication of a full-scale X-rotor, its integration with the RSRA, and flight tests.

Among long range programs, NASA plans further investigations of the oblique wing, which can be pivoted in flight to various angles for greater aerodynamic efficiency at supersonic speeds while maintaining good efficiency at lower speeds. This year NASA completed a 38-flight program of the AD-1 research airplane, demonstrating the wing's low-speed efficiency. Next, NASA plans to incorporate the wing in a modified military aircraft for flight testing at speeds at least up to Mach 1.2. In a separate program, NASA contemplates flight tests of lightweight, high-performance wings for supersonic cruise flight that offer efficiency improvements of 30 to 50 percent at Mach 2 and beyond. NASA will also develop a technology base for a supersonic STOVL (Short TakeOff and Vertical Landing) aircraft capable of operating from a variety of bases, including small ships and damaged runways.

What's Next in NASA Space Operations



Next year NASA will attempt to "capture" and repair in orbit the malfunctioning Solar Maximum Mission spacecraft. The artist's concept shows an astronaut equipped with a Manned Maneuvering Unit docking with Solar Max.

Coming up in the spring of 1984 is an important "next step" in the U.S. development of space capability: the first demonstration of the Space Shuttle's ability to retrieve orbiting satellites for servicing on the spot or return to Earth for refurbishment, thus allowing a lengthy extension of a satellite's working lifetime. The initial retrievee is the Sun-studying Solar Maximum Mission spacecraft, which has been producing only limited data since the 1981 failure of its attitude control system.

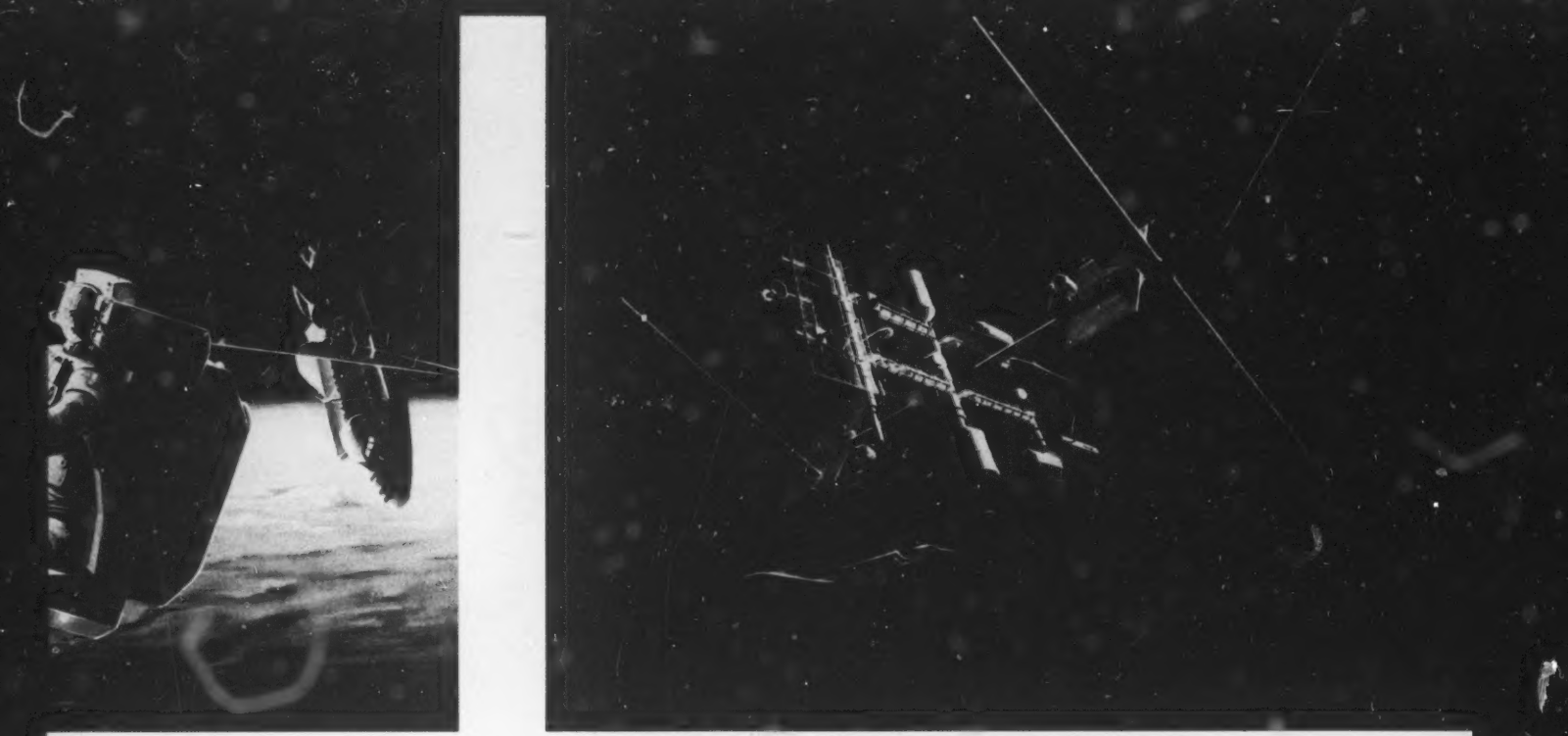
Launched in 1980, Solar Max was the first satellite designed for retrievability; it has a fitting that the Shuttle Orbiter's robot manipulator arm can grapple to haul the spacecraft into the Orbiter's cargo bay for replacement of the attitude control module. The task sounds simple enough, but it's really a very challenging and somewhat risky mission. Solar Max is not stable; it is sort of slow-rolling its way in orbit. Remember, although space operations sometimes appear to be conducted in slow motion, both the Shuttle and the satellite are moving at 17,500 miles per hour; even a slight bump from the corkscrewing Solar Max could be disastrous to the Shuttle crew. So the Orbiter must maintain a safe distance while someone goes out—literally—to stabilize Solar Max.

The someone is Mission Specialist Dr. George D. Nelson, who will be flying the Martin Marietta-built Manned Maneuvering Unit (MMU), a one-man backpack spacecraft that provides space suit pressurization, flight controls and thrusters for maneuvering. Nelson will fly solo to Solar Max, grasp its retrieval fitting, then fire his MMU thrusters to correct the satellite's rolling motion. With Solar Max stabilized, the Orbiter can move in close enough for the robot arm to capture the satellite. After repair, Solar Max will be redeployed in orbit to continue its study of solar phenomena.

Although manned extravehicular activity will figure in future retrieval servicing operations, much of this work will be taken over by a new vehicle known as the Teleoperator Maneuvering System (TMS). The TMS is a robot with manipulating arms and its own propulsion system; its maneuvers and manipulations are human-controlled from the Shuttle Orbiter, an Earth station or a space station. It will be used to deposit payloads in orbit, to inspect and photograph satellites already in orbit, to grapple and return them to the Orbiter or space station, or to serve as a free-flying subsatellite operating near an Orbiter or a space station. Planned for a developmental start in Fiscal Year 1985, the TMS could be operational by 1988.

NASA plans a number of improvements to the Shuttle itself, including provisions for additional life support and power supplies to extend the Orbiter's time in space to two weeks by the latter 1980s. Another improvement contemplated for the 1980s is the Aft Cargo Carrier, a container that would fit below the Shuttle's external fuel tank and allow a big increase in the volume of cargo the Shuttle can deliver to orbit. Looking farther down the road, NASA is studying a Shuttle-Derived Cargo Vehicle to carry large, heavy payloads from the ground to low Earth orbit in the era of the space station. Targeted for service about 1994, it would be an unmanned vehicle based on the Shuttle's boost system, with a huge payload canister substituted for the Orbiter.

One of the most important systems on the development agenda is the Orbital Transfer Vehicle (OTV), a high energy upper stage that would be reusable. Permanently based at a space station, OTVs would be used initially to boost heavy payloads from low Earth orbit (LEO) to geosynchronous Earth orbit (GEO), the 22,300-mile altitude where most commercial satellites operate. Later, an OTV fitted with a Teleoperator Maneuvering System would allow retrieval and servicing of satellites in GEO, which is far beyond the Shuttle's altitude capability. However, a real capability for GEO servicing and repair will demand human presence; toward that end, NASA is thinking of an advanced OTV that would include a crew capsule along with a tele-



The next giant step: a multimodule, human-habitable space station, the initial version of which could be in service by 1991. This is one concept —by TRW Inc.—that emerged from a recent round of industry studies.

operator system.

For the foreseeable future, the Shuttle Orbiter's time in space will be limited to about two weeks. But some science and applications payloads require much longer duration, years in some cases. Rather than fly many such payloads individually, NASA is planning a system whereby a number of long duration payloads would be aggregated in a large unmanned space platform. The platform will supply electrical power, communications, attitude control and thermal control for all of its multiple payload pallets. One Shuttle-serviced platform would, in effect, replace several individual satellites, providing large scale economies. The first platform, operating in LEO, is targeted for the latter 1980s; the plan contemplates later development of multipayload platforms in GEO.

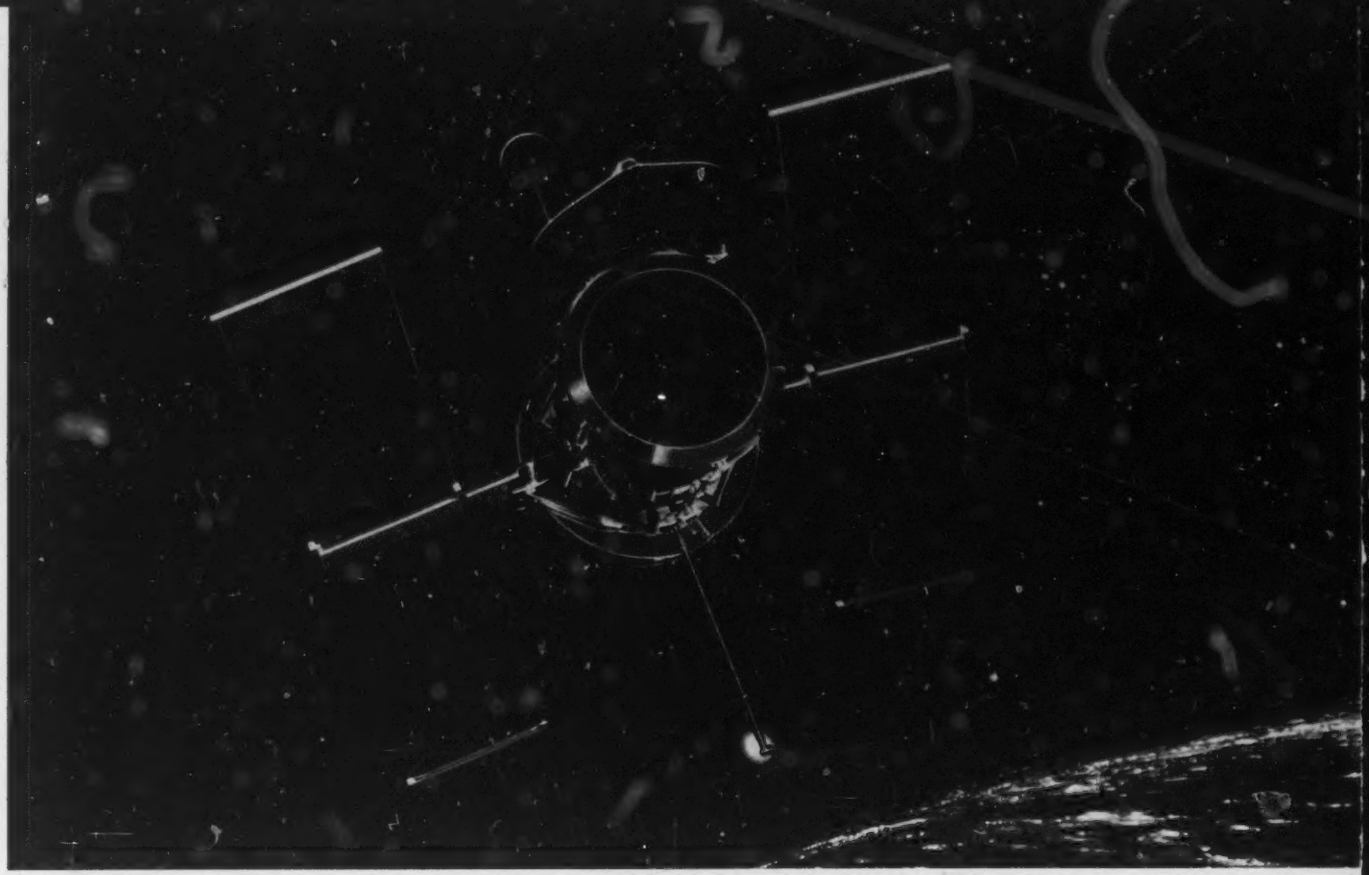
A major advance planned is development of Shuttle capability for erecting in orbit structures too large to be boosted from Earth—very large antennas, for example, or factories for manufacturing in space, or facilities for periodic human presence in GEO. A first step, to be tested about 1987-88, is the Deployable Antenna, Shuttle-delivered as a compact package that unfolds in orbit to a dish half the size of a football field. In the mid-1980s, NASA will begin experiments in erecting even larger structures by assembling segments produced by a Shuttle-based automated beam builder.

The key element in advanced space operations is, of course, the permanent manned station in low Earth orbit. NASA is now developing "architectural options," blueprints for a modular-design station that could be expanded over time by addition of habitable modules, supply modules and other equipment. If the Administration and the Congress signal a go-ahead by the time the program definition phase is completed in 1985, the initial station could be in service by 1991. It would allow continuous, rather than intermittent, space operations; it would provide a platform for human-directed scientific experiments and direct benefit systems; it would be a departure point for boosting payloads to GEO or for missions to the planets, asteroids and comets; it would serve as a base for assembly, deployment and servicing large spacecraft and multifunction platforms; it would house facilities for space manufacturing; and it would be the supply and operations center for space construction work.

Since all these plans are dependent upon annual appropriations, the timetable is necessarily imprecise, but NASA's Program Plan suggests these targets:

- **The 1980s:** improving Shuttle capability, conducting the initial series of Spacelab missions, increasing Shuttle launch frequency, servicing satellites in LEO.
- **1985-90:** introduction of the Teleoperator Maneuvering System, development of the Orbital Transfer Vehicle, first demonstrations of deploying large structures, initial operation of multifunction platforms in LEO.
- **1991-1995:** Operation of the initial space station, introduction of the OTV, payload servicing in both LEO and GEO, erection of large structures in orbit.
- **1996 to 2000 and beyond:** Deployment of multifunction platforms in GEO, development of a manned OTV for shuttle between LEO and GEO and, in the latter part of NASA's second quarter century, first operational use of a periodically-manned facility in GEO.

Accomplishment of these steps would allow continuous, efficient, routine operations in both low and high Earth orbit and set the stage for such currently considered but still remote possibilities as manned missions to the planets, unmanned probes beyond the solar system, or mining the moon and the asteroids for mineral resources to be processed at a lunar base or Earth-orbiting space colony.



Operating above the distorting influence of Earth's atmosphere, the Space Telescope will be able to "see" seven times farther into the universe than the best ground-based telescopes. It is slated for launch in 1986.

What's Next in NASA Space Science

In September 1985, a comet called Giacobini-Zinner will approach Earth on its path past the Sun. NASA's ISEE-3 spacecraft will be there to meet it, fly directly into its tail and send data to Earth on temperatures, gases, particles and magnetic forces. This will be the first close-up investigation of a comet, a particularly important area of space science research because comets are apparently little changed by time, thus offer clues to cosmic material as it existed in the solar system's earliest days.

A few months later, Comet Halley will make its once-every-76 years close encounter with the Sun. The European Space Agency (ESA), Japan and the Soviet Union will send spacecraft to "interview" Halley. Budgetary considerations precluded NASA's development of a Halley mission, but the U.S. will nonetheless be very active in Halley observations. ISEE-3 may be able to provide some data, and NASA is also participating in the ESA mission, named Giotto. Additionally, the U.S. and Germany will sponsor an International Halley Watch that will involve collection and analysis of data acquired by all nations' spacecraft, aircraft, balloons and Earth-based facilities.

Comet study is one part of NASA's program of interplanetary exploration, now known by the broader tag "exploration of the near universe." The aims of the program are to determine the origin and evolution of the solar system, to learn more about Earth through comparisons with other bodies in the solar system, and to investigate resources on the planets, moons and asteroids toward their possible future utilization. In addition to the comet investigations, these projects are already in being or in development:

- Pioneer 10 and 11, having almost concluded a grand tour of the outer planets, are at the edge of the solar system, still reporting data and about to move into interstellar space. Pioneer 10 is already beyond the outermost planet, but technically it will not depart the solar system until 1986. In fact, no one knows just where the solar system ends and the two Pioneers are providing data toward determining the boundary.
- Voyager 2 is en route to a 1986 flyby of Uranus and a 1989 encounter with Neptune; neither planet has been visited by spacecraft. The companion Voyager 1 will help the Pioneers define the solar system boundary.
- The Galileo spacecraft, comprised of a Jupiter-orbiting observatory and a probe to descend into Jupiter's atmosphere, will be launched in 1986.

Intended for service in 1988, the Venus Radar Mapper will map the never-seen surface of cloud-shrouded Venus with far greater clarity of detail than was possible with the earlier Pioneer Venus.

- A joint ESA/NASA International Solar Polar Mission is to be launched in 1986; the ESA-built spacecraft will explore a virgin area of space by flying around the Sun's poles, rather than in the solar equatorial plane where all prior spacecraft operated.
- The Venus Radar Mapper, to be Shuttle-launched in 1988, will map Venus' surface with a clarity of detail significantly better than the maps provided by the earlier Pioneer Venus.

In addition to these programs, NASA contemplates developmental starts, within this decade, of a Mars Geochemical/Climatology Orbiter to expand knowledge of the Red Planet; a rendezvous and long-duration closeup study of a comet; and a mission to map and probe the atmosphere of Saturn's largest moon Titan, which offers what may be the only atmosphere in the solar system similar to Earth's before life started on this planet.

For the years beyond 1990, NASA is thinking of advanced long-duration orbiter/probe missions to Mars and Venus; the first closeup look at an asteroid; a sample return from a comet; and orbiter/probe flights to Saturn and Uranus. Beyond 2000, NASA accords high priority for flyby/probe missions to Neptune and Pluto.

In 25 years of spacecraft operation, scientists have accumulated an immense volume of data about Earth, but it only underlines how little we know of the complex forces that govern our planet. There is need for a thorough understanding of these forces, not only for scientific gain but for an underlying practical reason—protecting the future habitability of the planet. NASA has embarked upon a comprehensive multi-mission study of the processes that link Earth and the Sun—how energy is transported to Earth, how the energy transfer influences Earth environment, and, in particular, how human activities may effect the physical processes that take place in a near-Earth zone known as geospace.

Several spacecraft are already providing data in this area. Among new programs in development or planned are the Earth Radiation Budget Explorer, to be launched next year for a study of the factors that determine Earth's climate; the Upper Atmosphere Research Satellite, planned for launch late in this decade, which will make global observations of the chemical composition and energy transfer mechanisms in the upper atmosphere; and the Origins of Plasma in the Earth Neighborhood (OPEN) program, in which four heavily instrumented laboratories, operating as a team, will conduct the first quantitative study of the complete geospace system and the interactive behavior of its various components.

Another area of space science is study of the distant cosmos toward knowledge of how the universe is structured, how it is changing, how it began and whether it will have an end. The key program in this study is the Space Telescope; planned for 1986 launch, it will look seven times farther into space than the best Earth telescopes and detect objects 50 times fainter. The Space Telescope may permit astronomers to see to the very edge of the observable universe and it will literally allow scientists to look back in time billions of years, because the light they will be viewing was generated long before our solar system was created.

Visible light, however, represents only a small portion of the radiation emanating from space, much of which is absorbed or filtered by Earth's atmosphere, hence is largely invisible to ground observatories. To complement the findings of the Space Telescope, NASA is developing a series of imaging spacecraft that will make observations in the non-visible infrared, x-ray, ultraviolet and gamma ray regions of the spectrum. The first, already in orbit, is the Infrared Astronomical Satellite (IRAS), which recently made headlines by discovering what may be another solar system around the star Vega. A more sensitive follow-on to IRAS, to operate from the Shuttle Orbiter starting late in this decade, is the Shuttle Infrared Telescope Facility.

Among other new astronomy projects planned or in development for launch over the next 10 years are ROSAT, a U.S./Germany x-ray investigator; the Gamma Ray Observatory, which will study how gamma rays are generated and where they come from; the Cosmic Background Explorer, the first spacecraft designed specifically to seek data on the beginnings of the universe; and the Advanced X-ray Astrophysics Facility, which will have instruments with about 100 times the sensitivity of those in prior x-ray spacecraft. Collectively, these and other astronomical systems will enable study of infant stars and dying stars, cosmic dust clouds where new stars may be forming, and the little-understood processes involved in the creation of galaxies, quasars and black holes.

What's Next in NASA Space Applications

In 1963, NASA pioneered the use of the geosynchronous orbit that allows a satellite line-of-sight communications with Earth for 24 hours daily, where earlier satellites could send signals only when they were "in view" of a ground station. The NASA technology provided a foundation for the commercial communications satellite networks that followed, so far the broadest area of direct benefit to emerge from applications of space technology to Earth needs.

Since 1963, about 150 communications and other satellites have been launched into geosynchronous orbit—and therein lies an incipient problem. Since all geosynchronous satellites operate at the same altitude—22,300 miles—the GEO orbit is becoming crowded and proximity can cause one satellite's signals to interfere with another's. The problem is not yet acute, but it bids to become so with an estimated 350 GEO satellites slated for service by the end of the century.

To forestall a possible communications logjam, NASA is developing technology that would greatly expand the capabilities of communications satellites. One method of increasing space-relayed message capacity involves satellite generation of multiple "spot" beams, each focused on a narrow Earth region, rather than the wide beams now generated. The spot beams would "hop" in sequence from one ground station to another, transmitting in a rapid burst all the signals stored since the last time the beam covered that station. This hopping would occur thousands of times a second, so satellite communications users would be unaware of the interruptions.

The spot beam approach is analogous to adding new lanes to an existing highway for greater capacity. Another approach compares with building an entirely new parallel highway: opening a new frequency range in addition to the two now used. Known as the Ka-band, this frequency range offers five times the capacity of either existing band, but it is not currently used because it is highly susceptible to weather-caused interference. NASA's task is to develop means of preventing loss of signal quality in transmissions through thunderstorms. A new program called the Advanced Communications Technology Satellite will combine the spot beam and Ka-band approaches in a demonstration system planned for orbital tests in 1988.

NASA's work in communications technology represents one facet of what the agency calls its "applications" program, intended to produce direct public benefit by exploiting space technology. Other products of this program include the operational environmental and land resources survey (Landsat) systems operated by the National Oceanic and Atmospheric Administration, and the new SARSAT search and rescue system that monitors signals from downed aircraft or ships in distress.

Next year, NASA will orbit a new Landsat 5 to replace the malfunctioning Landsat 4; the agency may later opt to retrieve and repair Landsat 4. NASA continues to develop advanced instrumentation for land resources survey, but remote sensing emphasis will shift in coming years to determination of ocean circulation characteristics, which influence such practical matters as fish production, ship design, ship routing, storm and iceberg avoidance and climate changes. Under its TOPEX (Topography Experiment for Ocean Circulation) program, NASA plans to develop an ad-

Installed on the mid-deck of the Space Shuttle Orbiter, McDonnell Douglas Corporation's EOS experiment is pioneering space production of advanced pharmaceuticals. Processing materials in the gravity-free space environment holds promise for manufacture of a broad range of superior Earth products.

vanced sea-monitoring satellite for launch late in this decade.

Of all the practical applications of space technology, the one with the broadest potential for Earth benefit is materials processing in orbit. Orbital processing —or space manufacturing—allows production of a great range of items not producible on Earth because of the adverse effects of gravity and air. In space there is no atmosphere and virtually no gravity; since there is a minuscule gravitational effect, scientists prefer the term "microgravity" to "zero gravity," but for practical purposes orbital operations can be considered gravity-free.

The most notable advances in space processing thus far have been in the EOS program conducted by McDonnell Douglas Corporation and its EOS partner—Ortho Corporation, a division of Johnson & Johnson—in cooperation with NASA. EOS stands for Electrophoresis Operations in Space. In the medical/pharmaceutical field, electrophoresis is a widely-used process involving electrical stimulation of a biological substance to separate the constituents of a mixture. It is used, for example, in blood tests—but not in pharmaceutical production because only a very small amount of material can be extracted at one time.

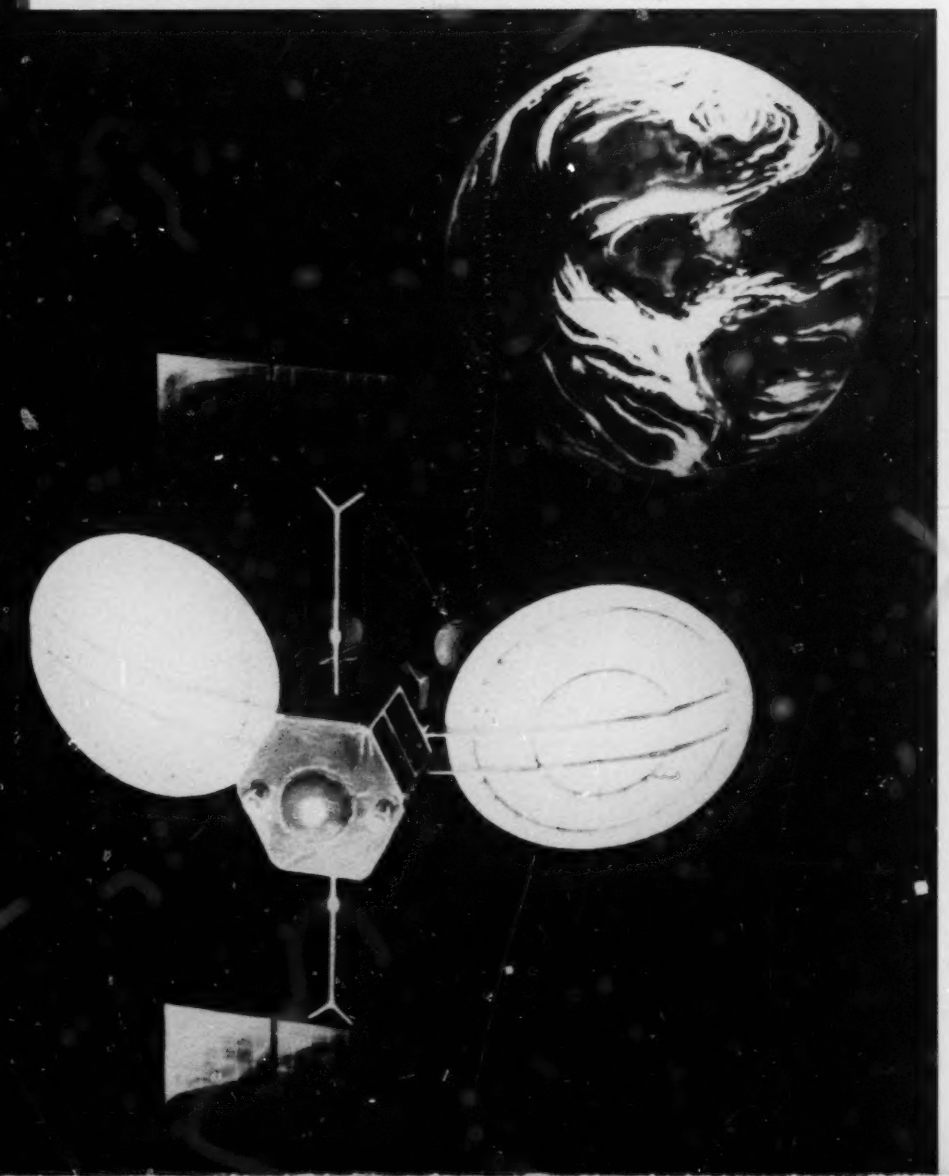
In Shuttleborne tests, the automatic EOS equipment demonstrated that it can produce more than 400 times the amount of material that could be extracted from similar Earth processing. Additionally, there are indications that the absence of gravity can increase the purity of the processed material as much as five times. This combination of vastly increased output and much improved purity may open the door to an entirely new family of space-processed pharmaceuticals for more effective treatment of disease.

The rapid advance of EOS technology suggests that McDonnell Douglas/Ortho could be ready to start pharmaceutical production in this decade. The question is what to use as a manufacturing facility; manufacturing operations will require more time in orbit and more working area than the Space Shuttle can provide. The manufacturing facility can be an unmanned, free-flying, Shuttle-tended spacecraft but, since human supervision would greatly enhance processing efficiency, the optimum factory is a human-habitable module aboard the space station NASA is planning.

Pharmaceutical production is only one of many possibilities. Orbital processing offers potential for producing a wide range of materials with properties vastly superior to similar Earth products, for example, stronger, lighter and far more temperature-resistant metallic alloys for a multitude of applications, or silicon crystals with enormously improved electrical properties for such applications as computer memories, solar cells, lasers, optical communications and many types of industrial and scientific instruments. Orbital operations also offer the interesting possibility of processing certain materials that demand extreme purity—glass for lasers or optics, for example—without use of a processing container; the materials would be melted, shaped and solidified while they float freely in space and the resultant product would be extraordinarily pure due to elimination of container-caused contamination. In a lengthy series of Shuttle tests already under way, NASA is exploring these and other possibilities.

Studies show that there are about 500 materials that could be greatly improved through orbital processing, and there are some 250 companies interested. So far only a few are actually engaged in research projects; one major reason is a reluctance to invest due to uncertainty as to future availability of space manufacturing facilities. A government commitment to development of a space station with manufacturing modules could provide the impetus to a new wave of the industrial revolution.

With the Advanced Communications Technology Satellite, planned for 1988 launch, NASA will test new ways of expanding communications satellite capabilities to forestall a possible space communications logjam in the 1990s.



In the past quarter century, we have undergone a revolutionary transformation in space technology. We need only compare the small and primitive Explorer 1, America's first satellite, to the sophisticated, manned and reusable Space Shuttle to grasp this fact. Today's Shuttle is but one element in a large and growing family of space applications, each of which has provided numerous benefits to mankind. Military space systems have helped to secure the peace and developments in the civilian and commercial sector have led to increased farm production and to greater efficiency in business practices.

In the years ahead, space holds the promise of improving the human condition further. But this can occur only if we develop the ability to better manage this technology. The evidence to date, however, suggests that space technology is progressing at a greater speed than man's ability to manage it; while technology continues to mature, our management methods have not. As I see it, there remain at least two major areas where policy has yet to catch up with the requirements posed by space systems and their applications.

Managing International Competition

Telecommunications satellites comprise a critical element of U.S. interests in space. Our ability to communicate internationally has a direct bearing not only for defense but also for U.S. foreign and economic interests.

A recent Commerce Department study, completed at the request of the Senate Commerce Committee, documents long-range problems as the United States adapts its international telecommunications policies to a changing political and technological environment. This study emphasizes several significant problems, including:

—a trend towards the politicization of international telecommunications organizations, where the focus on extraneous disputes, such as the Middle East situation, has led to the neglect of pressing telecommunications problems;
—a growing unsympathetic attitude towards U.S. needs and interests by other member nations of international telecommunications bodies;
—an inability of U.S. policy-making agencies to meet this challenge through effective policy-planning and coordination.

Americans communicate with other nations in one of two ways: through undersea cables or geostationary satellites. Intelsat, jointly owned and operated by 108 countries, governs international satellite system operations. In 1965, NASA launched the first international communications satellite for Intelsat. This satellite provided 240 voice circuits. In the last two decades, this technology has advanced rapidly. The Intelsat satellite launched in 1981 has 12,000 voice circuits and two color television channels. A new satellite scheduled for 1986 launching will provide 36,000 voice circuits. Unfortunately, the governing organizations have not advanced as rapidly or as efficiently as the technology they govern.

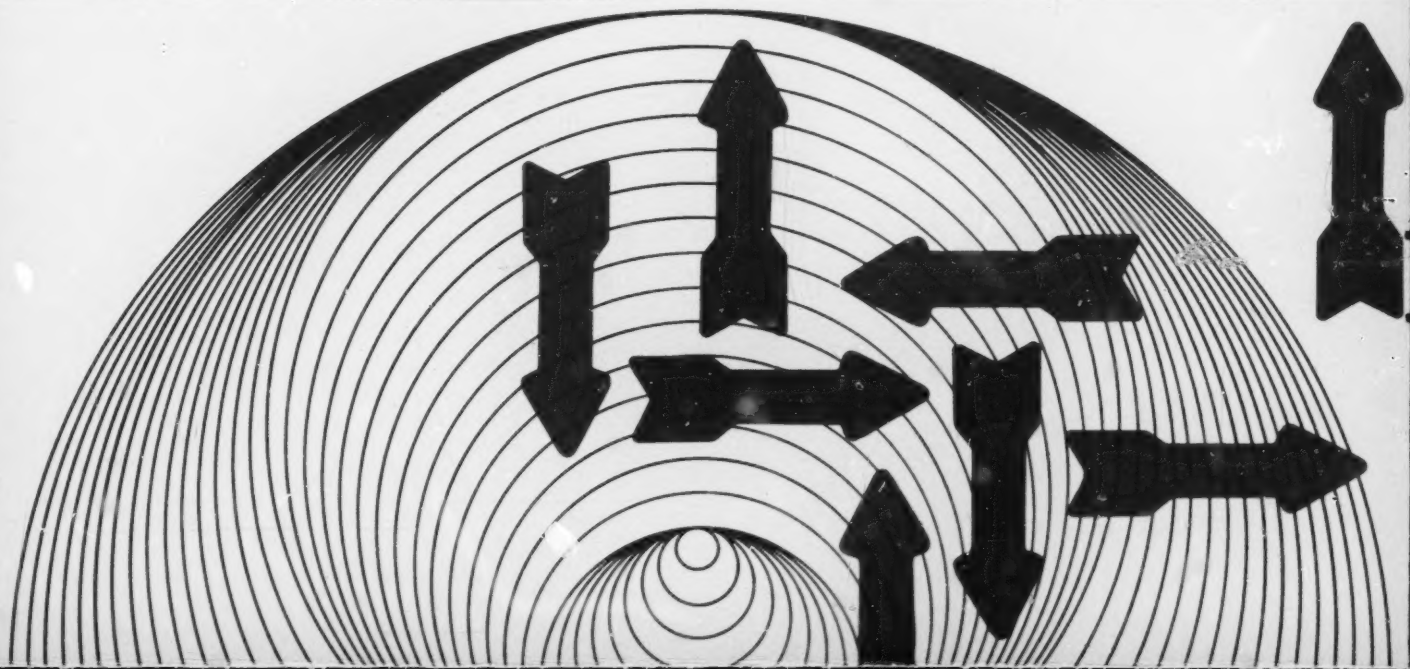
The International Telecommunication Union (ITU), with 157 member nations, meets regularly to determine orbital space assignments and radio frequency spectrum allocations. As more nations have access to sophisticated satellite technology, the demand for spectrum allocations increases. There is a growing conflict between developing nations, which predict a future increased spectrum need, and post industrial nations like the United States, which already have a growing and immediate need for additional spectrum space.

As the Commerce Department study points out, the ITU has become increasingly politicized as a result of its one-member, one-vote policy. Recent ITU conferences have shifted focus from legitimate communications matters to a stalemated debate on unrelated foreign policy issues. In the midst of this turmoil, the United States' interests may be slighted.

For example, last year the Federal Communications Commission authorized the development of direct broadcast satellites. This new broadcast service promises new communications potential, particularly for remote rural communities. DBS transmits a signal directly to a small Earth station located in a backyard or on the roof of a building. It is not dependent on a cable wire or a telephone pole.

However, DBS requires specific spectrum allocation—to be determined by the ITU. Here is an example of a technology available for immediate use in this country, but its development is dependent on the decisions of an international forum which is increasingly hostile to U.S. interests.

In the meantime, U.S. policymakers appear slow to develop a coordinated federal posture for these international conferences. Thirty western nations met in Geneva this spring and summer to devise a plan for DBS spectrum use. Recent Congressional committees have heard testimony critical of past and current conference preparations. The head of the U.S. delegation to the ITU conference last fall



described policy preparations as inadequate and suggested that the United States take seriously the need to prepare a thorough and long-range plan for advancing our international telecommunications interests. The Commerce Department study makes similar suggestions.

Failure to correct this situation will seriously weaken U.S. leadership in this vital area. As a first order, the Congress and the Administration must examine the current policy-making structure and act quickly to make those changes that will make the United States an effective force in meeting this challenge. Our nation has the technological strength to hold its own in space. What is needed is an effective policy to back this up. Absent a coordinated approach at the federal level and a concerted effort to work, within existing or new international structures, we cannot provide the American public with the best communications system on earth.

Protecting the Common Good

As satellite technology matures, government should look towards the private sector to manage a larger share of space activities. While this rule makes sense in general, we must assure that its specific application serves the public interest. We face this dilemma with regard to the future of meteorological satellites and Landsat remote sensing satellites. Decisions now under review by the Administration could affect the lives of thousands of workers, billions in tax dollars, the balance of payments and national security.

Since the Administration's decision to commercialize our weather and land observation satellites, the proposal has come under close scrutiny in Congress. The commercialization issue is not a new one. I have been following it for a number of years, contacting study groups and advisory board members, submitting testimony and expressing my concerns about the possible ramifications of the transfer. It took a Presidential announcement about selling the satellites to bring the issue to the level of attention it has received recently.

In recent years, I have outlined and often reiterated my concerns over subsidy costs, monopolies, service to the public, employment and defense related problems with the transfer proposals. The numerous studies that addressed these considerations are in close harmony in their findings. This is what they have to say:

• *Subsidy costs.* The private sector market is not sufficiently developed to support the transfer. In fact, the proposal will cost the government $800 million more than it currently plans to spend over the next 10 years. A government study states that "there is no clear policy or financial benefit to be realized."

• *Monopolization.* There is no doubt that total transfer to a single corporation would result in a monopoly. The studies point out that creation of a single, government subsidized monopoly (as is proposed) would be against U.S. economic philosophy. One study states that "commercialization *now* could inhibit the free market process."

• *Public service.* Portions of the weather information that we now receive free would have a price tag on it. The U.S. taxpayer has already paid for these services. I think it would be unfair to let a corporation charge a second price.

• *Employment.* It is possible that many government employees would lose their jobs as a result of commercialization. Although it is true that some of these positions would be replaced in the private sector, there would almost definitely be a net decrease in employment. It would be hard to justify a proposal that eliminates jobs, costs the government additional money, and hands ready-made monopolies over to a single corporation.

• *National Security.* The Defense Department is seriously concerned that a transfer could jeopardize U.S. security interests. For instance, meteorological data is vital for planning force deployments, war planning and intelligence. These security considerations argue for continued government control of weather forecasting capabilities.

The evidence indicates that we are not yet ready to commercialize our land and weather satellites. Still, a decision to commercialize has been made. As someone who has been actively involved in this issue for many years, I believe that a reassessment is in order.

If the private sector could operate the satellites in a true free market atmosphere, if there are, indeed, government savings; and if we can continue to provide the same level of service that the American people deserve, then we have an entirely different and much more acceptable package than is before us today. But I see none of those elements in any of the current commercialization proposals. Unless there is some new and startling evidence that has escaped me, I will continue my fight against this transfer.

U.S. SPACE POLICY:

THE NEED FOR NEW DIRECTIONS

By SENATOR LARRY PRESSLER

Elected to the Senate in 1978, Republican Larry Pressler, 41, is senior Senator from South Dakota. He is a member and subcommittee chairman of the Senate committees on Foreign Relations; Commerce, Science and Transportation; Small Business; and the Special Committee on Aging.

MAKING HISTORY AT PAX RIVER

By LAURA OVERSTREET

Sixty miles southeast of Washington, D.C., on a peninsula that juts into the Chesapeake Bay, aerospace contractors are working side by side with naval engineers and pilots to advance the state of the art in naval aviation.

The degree of sophistication and the importance of activity at Patuxent River Naval Air Test Center belie the tranquility of an area only seven miles from the site where the first Maryland settlers landed in 1634.

At Pax River history is still being made.

More than 500 test projects are concurrently underway on an inventory of 100 aircraft representing 30 different types in 50 differing configurations. They include fighter, attack, trainer, patrol, early warning, electronic warfare and rotary wing aircraft that serve in flying testbed, chase, target, tanker or search and rescue roles. In addition to these test planes, the airfield accommodates more than 40 operational aircraft. The mission at Pax River is testing and evaluation (T&E) of some of the nation's most sophisticated aircraft and systems.

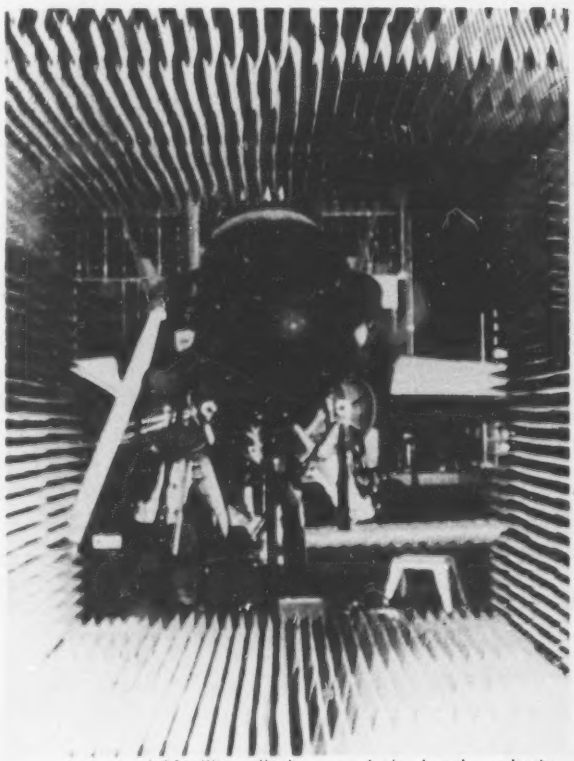
Opened in 1945, the Naval Air Test Center has operated cooperatively with the aerospace industry since 1978 under the "single site" concept, wherein contractors rent aircraft hangars and test facilities from the Navy and conduct their own testing simultaneously with Navy evaluations of the same systems, exchanging information and eliminating redundancies. The results are savings in time and money for both the Navy and its contractors and a system of checks and balances leading to improved equipment.

At least twenty-two member companies of Aerospace Industries Association have on-going projects at Patuxent River. These include full-scale development of the McDonnell Douglas AV-8B Harrier II and follow-on test and evaluation and fleet support projects on the McDonnell Douglas F/A-18, Sikorsky SH-60B LAMPS Mk III, Grumman E-2C, Grumman A-6E and EA-6B, Lockheed P-3C, Lockheed S-3A, Grumman F-14A, McDonnell Douglas F-4, and the Sikorsky SH-3, Bell UH-1, Boeing Vertol H-46, and Sikorsky CH-53E helicopters.

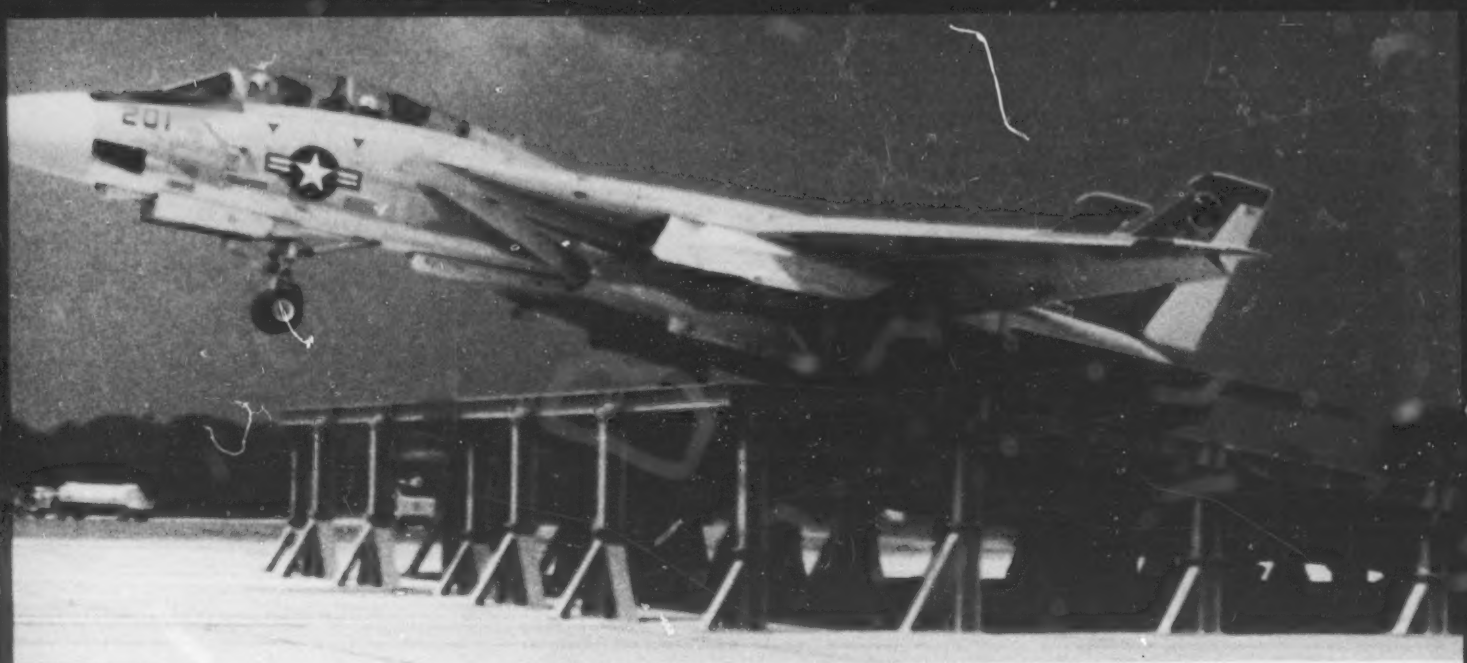
The rigors of the naval aviation mission require strict specifications. The world of the naval aircraft carrier offers a potentially hostile physical environment to the sophisticated aircraft operating from its decks. Electrical components for carrier aircraft must be small, lightweight units which consume little power and have sufficient reliability to operate hundreds of hours without malfunction, even under unusual stress. These units must be readily repaired, with the help of unobstrusive built-in test circuitry, and rugged enough to withstand the shock of catapult launches and arrested landings.

Such rigid requirements demand a close cooperative relationship between

Close teamwork between Navy and contractor personnel is the hallmark of the Naval Air Test Center, where new aircraft—such as the McDonnell Douglas F/A-18A Hornet pictured—undergo development testing.

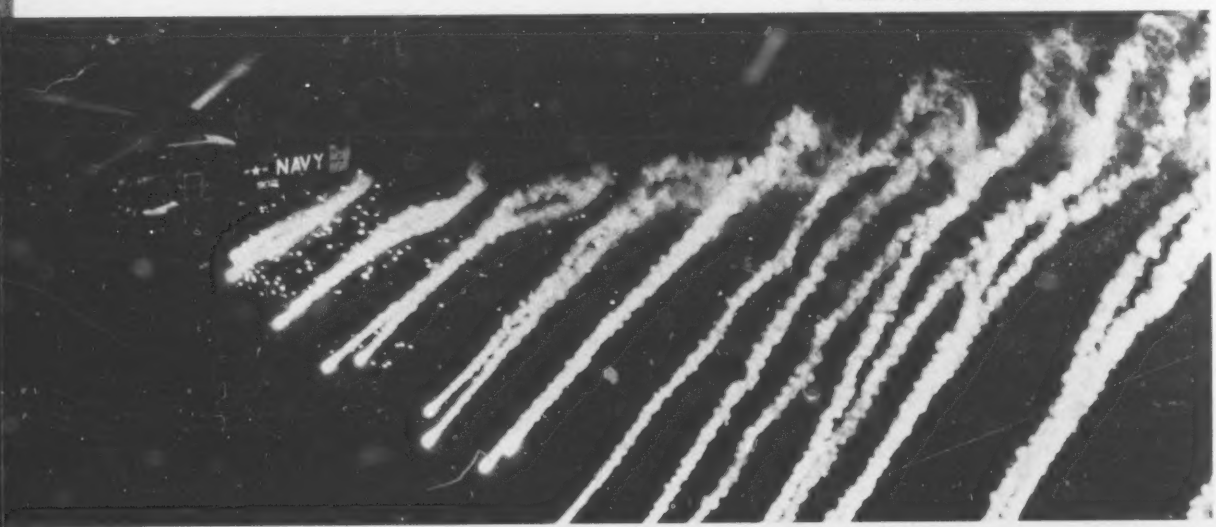


In a special facility called an anechoic chamber, electromagnetic measurements are made on an airborne radar.



A Grumman F-14A Tomcat leaps from a ramp elevated nine degrees in a test to determine feasibility of "ski jump" takeoffs for conventional jets.

A Kaman SH-2F Seasprite dispenses flares in an electronic countermeasures test.



A Lockheed P-3C Orion drops a lightweight torpedo in a separation test.

The Naval Air Test Center's Range Computation and Control System permits air controllers to pinpoint the positions of a large number of aircraft operating in the test range.

contractors and their Navy client. This relationship begins—long before the Pax River phase—with a mission requirement and a concept of what is needed to fulfill that requirement. It continues until the life cycle of the system is complete and the system no longer meets the mission requirement. The interim is a constant process of evaluation and improvement.

To find a source to build the system that will meet the mission requirement, the Navy Contracting Office sends out a Request for Proposal, or RFP. In effect, the RFP states that the Navy needs a certain piece of equipment that will meet specifications of size, range, speed, durability, and other details. RFPs are distributed to companies on a bidder's list and published nationwide in the Commerce Business Daily, a government publication.

Aerospace companies may respond with offers to meet the need. The Navy selects those that seem most likely to fill the requirement and requests further information. From the responses, the Navy may choose several to receive research and development contracts for building prototypes of the system under consideration. Once the prototypes have been built, a flyoff is held. The Navy eventually selects one system for full-scale development under Navy funding. In the case of aircraft, perhaps 10 planes will be hand built; these 10 are assigned to Pax River and the T&E process begins.

Most development aircraft are specially equipped to test specific requirements. One or more will be equipped to function as a fully mission-capable system. Both contract and Navy pilots fly the aircraft, expanding its performance envelope to the limit and beyond, in order to determine the full potential of the airplane and its components.

Project assignments may include tests on airborne radars, navigation and digital display systems, electronic warfare systems, on-board test equipment, and electro-optical sensors. Also tested are such ancillary segments of the performance envelope as engine airstarts, shipboard launch and recovery, in-flight refueling, armament carriage/separation and aircraft gunfiring.

It is here that communication between pilot and engineer, contractor and naval personnel is so important. Minor engineering or structural changes to test planes can be made on-site at Patuxent River, saving time and money, and incorporated simultaneously into production models at the contractor's plant. Major modifications, quickly identified through exchange of information, are performed at the aircraft or component manufacturer's production facility.

Test and evaluation goes beyond the development aircraft at Pax River. From operational T&E squadrons at Point Mugu and China Lake, California, and at Patuxent River, operational test pilots and engineers put production models through realistic operational scenarios, using operational maintenance support. Wartime tactics are developed to exploit the fullest potential of the aircraft's mission. Operational T&E never ends. Once the aircraft is in the fleet and functioning on carriers around the world, performance monitoring provides feedback to the engineers at Patuxent River, where testing and modification continues.

Pax River testing is monitored by the latest in computer equipment. The Center's real time data telemetry station receives up to 512 independent data measurements from each of four aircraft operating simultaneously; each of the four channels samples data measurements at rates up to 50,000 times per second and each can operate from airborne recorded tapes or telemetered data at a receiving rate of 1.2 million bits per second. The data is converted to corrected engineering units, subjected to flight safety checks, then displayed in real time to project engineers on one of four separate project engineering stations. The telemetry system monitors not only the vital signs of the aircraft under test but also tracks the performance of on-board systems.

While telemetry looks at what is happening inside the flying aircraft, the Chesapeake Test Range at Patuxent River provides exact positioning information on the aircraft through a Range and Computation Control System (RCCS). Resembling a Star Wars command and control center, the RCCS processes data in real time from a variety of sensors, including radar, theodolite and laser tracking systems, and displays the data on cathode ray tubes, or on a six-by-six foot four-color screen, or on mechanically-controlled printers and plotters. During a range test, such displays—manned by members of the Range Computation and Control Section—provide information for vectoring and controlling individual missions of up to four aircraft each. The large screen display provides for overall range coordination and safety analyses for as many as sixteen aircraft.

Other facilities at Patuxent River include a comprehensive avionics evaluation laboratory; a ground based TC-7 steam catapult; a full MK-7 arresting gear to test an aircraft's suitability for carrier operations under controlled conditions; and laboratories for design, fabrication, calibration, and testing of a wide variety of specialized airborne test instrumentation. Of the some 10,000 people who work at the Naval Air Test Center, nearly 3,000 worked for aerospace contractors.

There is another major activity at Pax River—the U.S. Naval Air Test Pilot School, one of only four pilot schools in the free world. Here in the 1950s and early 60s, history was made as Navy test pilots soon to be touched by destiny put their machines through the rigors of testing without today's sophisticated computerized monitoring. On their way to the space age, test pilots such as John Glenn, Al Shepard, Scott Carpenter and Pete Conrad hung their aircraft over the edge of technology high above Patuxent. Housing areas at Pax River bear such names as Glenn Vista, Shepard Court, Conrad Heights and Carpenter Park, reflecting earlier days of aerospace research and serving as historical backdrop to the challenges still being met at Pax River.

National Benefits of Aerospace Exports

In all the years of this century, the United States never experienced an international trade deficit until 1971. Since then, U.S. trade has been in the red 10 of 12 years and the amount of the annual trade deficit has been growing alarmingly. Last year it topped $35 billion, a record but a short-lived one; a higher deficit is already assured for 1983 and some forecasters think this year's figure might be more than double last year's. That's a nutshell summary of a U.S. trade picture that is causing deep concern in government and industry circles.

A bright spot amid the gloom has been the trade performance of certain high technology industries, in particular the aerospace industry, which recorded a trade surplus of $11.2 billion last year. But, says a report by Aerospace Industries Association's Aerospace Research Center, although the 1982 aerospace trade balance constituted a very substantial contribution to the U.S. economy, it nonetheless represented an inflation-adjusted decline of about 20 percent—and that "must be seen as a warning."

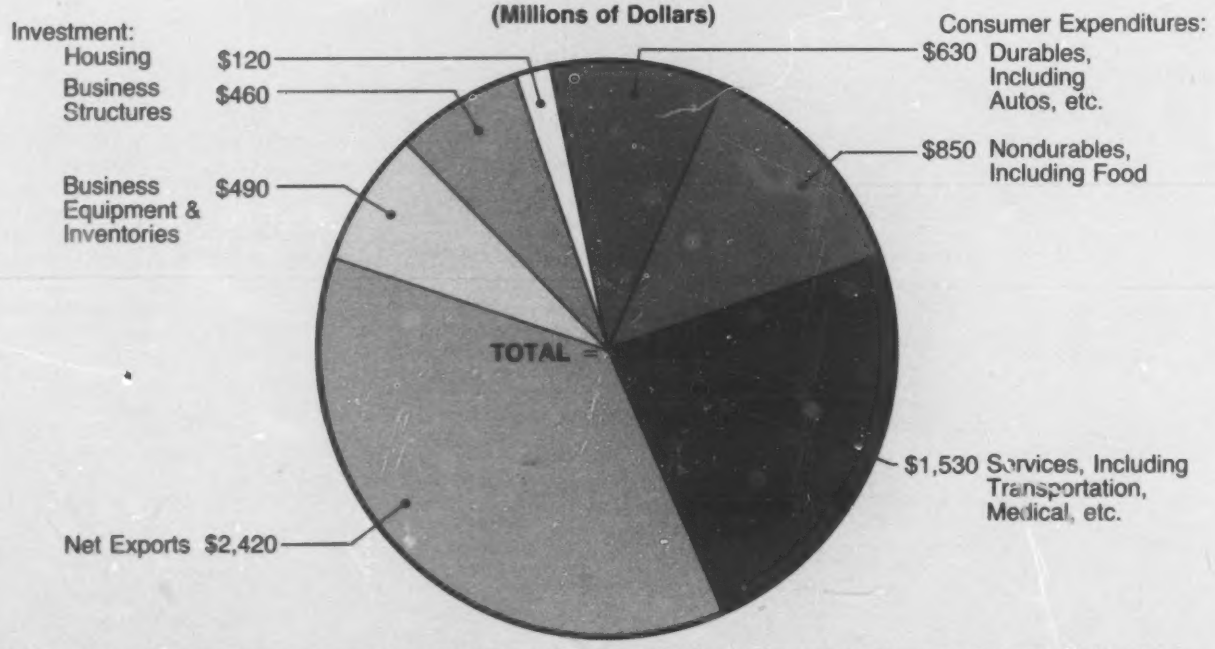
Entitled *National Benefits of Aerospace Exports*, the report states "there is a real possibility that the (aerospace) industry could yet be undercut—technologically and competitively—in world markets, as were other basic U.S. industries. Because high technology is one of the United States' largest remaining areas of competitive advantage in world trade, significant declines in aerospace trade— notably aircraft trade, the largest component of industry exports—would have serious implications for the economy and the nation as a whole."

Much of the 1982 aerospace trade decline—after several record-setting years—was attributable to the world recession, high interest rates, the financial problems of the world's airlines, and similar problems experienced by potential purchasers of general aviation aircraft and helicopters. But there were other contributing factors, among them increasingly aggressive competition from foreign manufacturers who enjoy the full support of their home governments. The report underscores the fact that "aerospace imports are of particular concern because their growth rate has been steeper than that of exports." In 1978, the value of U.S. aerospace imports was well below $1 billion; last year it was more than $4.4 billion.

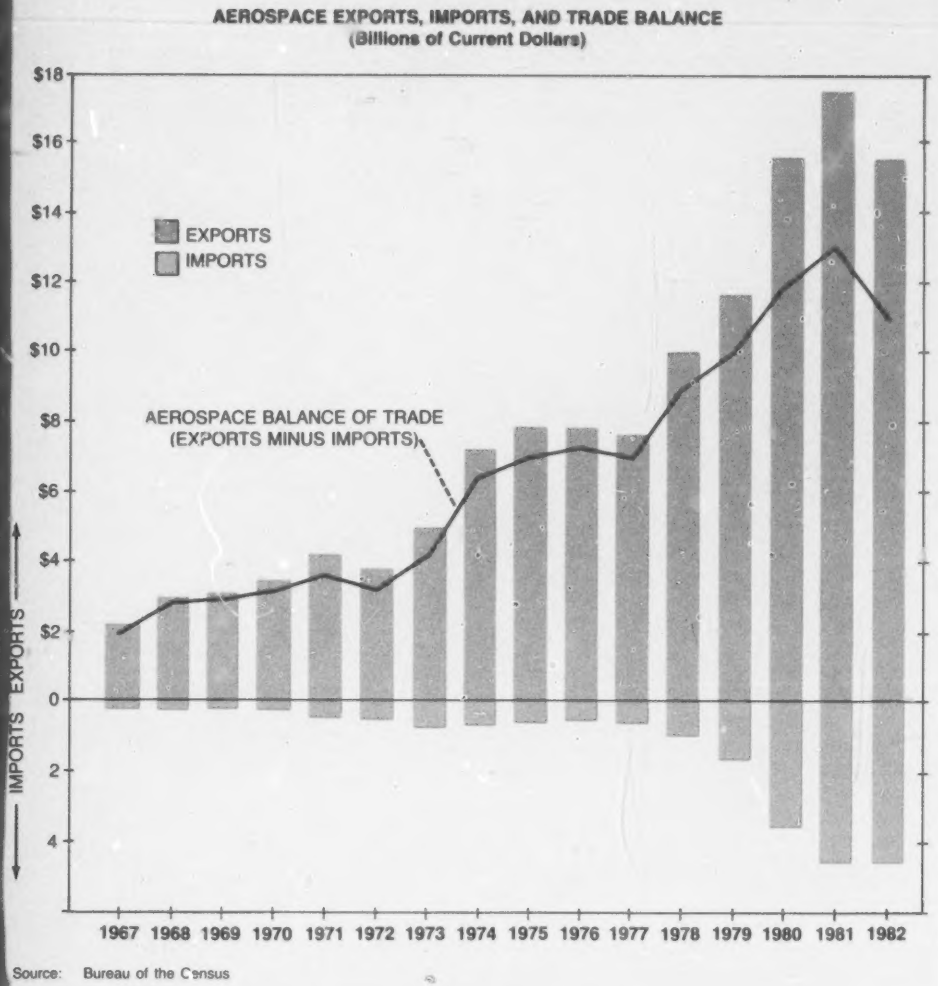
The combination of greater competition and other trade-influencing factors

This chart shows how a $1 billion increase in aircraft exports would generate a $6.5 billion gain in the Gross National Product over a nine-year span. It would also add more than 44,000 job-years in the aerospace industry and 104,000 job-years in other U.S. industries.

IMPACT ON REAL ECONOMIC ACTIVITY
FROM A $1 BILLION INCREASE IN AIRCRAFT EXPORTS
1982-1990
(Millions of Dollars)



Source: "The Economic Impacts of Increased Aircraft Exports" prepared by Chase Econometrics/Interactive Data Corporation, for the Aerospace Industries Association, June 1982.



Source: Bureau of the Census

Aerospace exports and trade balance grew impressively from 1967 until last year's decline. But U.S. aerospace imports have increased more rapidly in recent years.

is substantially impacting the U.S. aerospace industry at a time when it has invested billions in development of new-generation aircraft. "The United States must recognize this fact," says the report, "and respond appropriately to preserve the strength of a vital but potentially vulnerable (aerospace) industry." It adds these conclusions:

"In order to compete in an increasingly aggressive world trading environment, the United States must build on its competitive strengths, among them high technology exports. Aerospace products are a major component of that high technology advantage; the industry exports about a third of its product and the benefits to the U.S. economy, both direct and indirect, are significant...

"As foreign aircraft producers gain competitive strength, it becomes especially important to assess the returns from exports and to consider and take steps to strengthen the network of practices and policies that must assist aerospace and other industries to maintain their place in the market." Among steps that might be taken, the report suggests a review of antitrust laws for their impact on U.S. joint ventures and a need to explore tax and other incentives favoring R&D and innovation, toward effecting a substantial increase in U.S. R&D expenditures.

Continuing U.S. high technology competitiveness is important to economic growth, national security and employment. To quantify the extent of such benefits, AIA commissioned an independent and objective study—performed by Chase Econometrics/Interactive Data Corporation—of the impact of aircraft exports on the U.S. economy. The basic assumption of the study was a $1 billion increase in aircraft-related exports in 1982. That initial $1 billion, the study group found, would add 44,200 full-time equivalent (FTE) jobs in the aerospace industry; as a result of supplier sales and economic multiplier effects, the total impact would be 148,400 FTE man-years over the period 1982-1990.

Additionally, the initial $1 billion would generate a $6.5 billion increase in the Gross National Product, the largest increment of gain ($3 billion) reflecting increased consumption resulting from direct and indirect wage earnings. It would also boost government revenues through personal and corporate income taxes, social security receipts, state and local receipts, and it would contribute to reduced unemployment compensation payments and lower government interest expense. Over the nine-year period 1982-1990, the total reduction in the federal deficit, including interest expense, would be $3.7 billion in current dollars or $2.4 billion in 1982 dollars.

Other key benefits would accrue from an increase in aircraft exports:

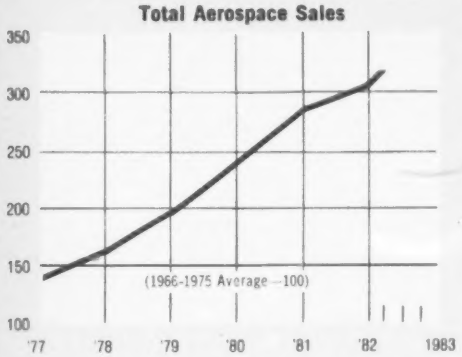
- Aircraft are high-value items, therefore especially important to the U.S. balance of trade.
- An existing large, well-trained high-technology labor force and well-equipped civilian aircraft manufacturing facilities represent national assets that would provide insurance in time of national emergency by enhancing "surge" capability, the industry's ability to step up production rapidly.
- Large-scale sales to foreign customers allow spreading aircraft production costs over a larger number of units, reducing unit cost and directly benefiting U.S. airlines and the U.S. government.
- R&D requirements for new aircraft, funded in part through export sales, generate technological advances that often find spinoff application in product areas other than those for which the technology was originally developed; such technology conversions create new product lines, sometimes whole new industries, with attendant benefit to the U.S. economy.
- A particularly important form of spinoff is civil/military "crossover," the sharing of knowledge between the industry's civil and military manufacturing segments. In the past, R&D crossover usually went from the military to the civil segment; today, the flow is more often in the reverse direction, especially from civil to military aircraft. Such crossover saves the taxpayers money while contributing to technological advancement in military systems.

Copies of *National Benefits of Aerospace Exports* are available from the Aerospace Research Center, 1725 DeSales Street NW, Washington, D.C. 20036.

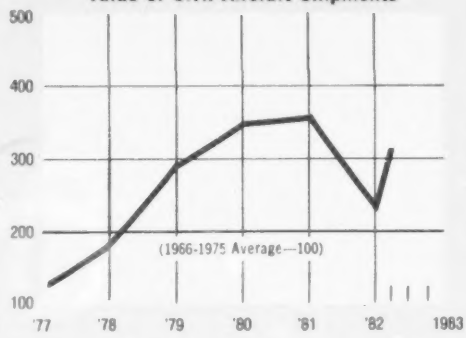
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales



Value of Civil Aircraft Shipments[r]



OUTLOOK

New Orders — Monthly Average

ITEM	UNIT	PERIOD	AVERAGE 1966-1975*	SAME PERIOD YEAR AGO	PRECEDING PERIOD**	LATEST PERIOD 1st QTR. 1983
AEROSPACE SALES: TOTAL	Billion $	Annually***	24.2	70.4[r]	74.1[r]	77.1
(as reported by the Bureau of the Census)	Billion $	Quarterly	6.1	16.7	20.4[r]	19.7
AEROSPACE SALES: TOTAL	*Billion $*	*Annually****	*25.6*	*35.4[r]*	*35.8[r]*	*36.8*
(in constant dollars, 1972=100)	*Billion $*	*Quarterly*	*6.4*	*8.2*	*9.7[r]*	*9.2*
AEROSPACE PRIME CONTRACT AWARDS: TOTAL	Billion $	Quarterly	5.8	19.4	24.0[r]	27.1
U.S. Government	Billion $	Quarterly	4.1	11.0	17.2[r]	21.1
Other Customers	Billion $	Quarterly	1.7	8.4	6.8[r]	6.0
BACKLOG (Major Aerospace Mfgrs): TOTAL	Billion $	Quarterly	28.6	96.0[r]	103.6[r]	111.7
U.S. Government	Billion $	Quarterly	15.9	45.5	58.4[r]	68.6
Other Customers	Billion $	Quarterly	12.7	50.5[r]	45.2[r]	43.1
DEPARTMENT OF DEFENSE						
Aerospace Obligations: TOTAL	Million $	Quarterly	2,712	8,747	8,850	11,045
Aircraft Procurement	Million $	Quarterly	1,986	7,015	6,604	9,045
Missiles Procurement	Million $	Quarterly	726	1,732	2,246	2,000
Aerospace Outlays: TOTAL	Million $	Quarterly	2,405	4,844	6,642	6,197
Aircraft Procurement	Million $	Quarterly	1,741	3,888	5,502	4,990
Missiles Procurement	Million $	Quarterly	664	956	1,140	1,207
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	1,688	1,515	1,778
Expenditures	Million $	Quarterly	789	1,155	1,289	1,299
EXPORTS						
Total (including military)	Million $	Quarterly	1,038	4,153	4,151	4,586
New Commercial Transports	Million $	Quarterly	345	1,410	688	1,630
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	1,178	1,150	1,146
Aircraft	Thousands	End of Quarter	650	626	601	582
Missiles & Space	Thousands	End of Quarter	114	125	130	139
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	10.93	11.77	11.64
PROFITS (after tax) BASED ON SALES						
Aerospace	Percent	Annually***	2.7	3.7	3.3[r]	3.3
	Percent	Quarterly	2.7	3.2	3.1[r]	3.2
All Manufacturing	Percent	Annually***	4.8	4.5	3.5	3.3
	Percent	Quarterly	4.8	3.8	2.8	3.2

*1966-1975 quarterly averages are computed as one-fourth of annual averages.
**Preceding period refers to quarter preceding latest period shown.
***Annual data are computed as the sum of the previous four quarters.
r Revised.

Source: Aerospace Industries Association

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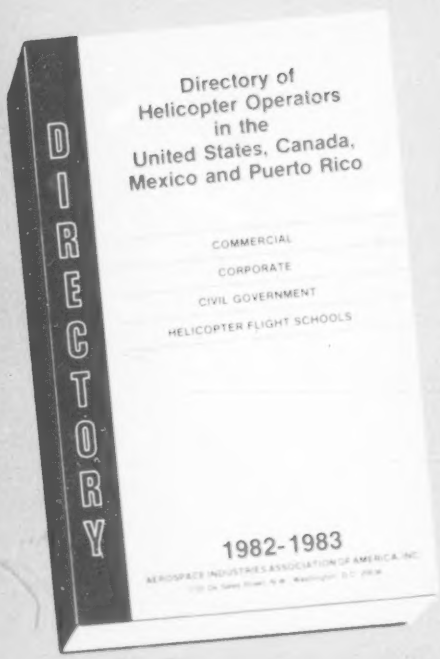

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